U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB-299 375

Coal Processing Technology Environmental Impact of Synthetic Fuels Development

(U.S.) Industrial Environmental Research Lab, Research Triangle Park, NC

1979

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO. EPA-600/J-79-023	2. JOURNAL ARTICLE	3. PB 299375
4. TITLE AND SUBTITLE Environmental Impact of Synthetic Fuels Development		5. REPORT DATE
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) T. Petrie and W. Rhodes (IERL-RTP)		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Same as 12.		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS **EPA, Office of Research and Development Industrial Environmental Research Laboratory Research Triangle Park, NC 27711**		13. TYPE OF REPORT AND PERIOD COVERED Journal Publication
		14. SPONSORING AGENCY CODE **EPA/600/13**

15. SUPPLEMENTARY NOTES Presented at the AIChe conference, Miami Beach, 11/12-16/78
Published in Chemical Engineering Progress, June, 79, Vol. 75, No. 6. pp. 73-80
FORMER TITLE: Environmental Aspects of Coal Gasification and Liquifaction Processes

16. ABSTRACT

This paper describes a portion of a comprehensive, long term EPA program to evaluate the environmental effects of energy systems that produce gaseous and liquid fuels from coal. The technologies being assessed include low-, medium-, and high-Btu gasification and liquefaction. One part of the program for which EPA/IERL-RTP is primarily responsible is the environmental evaluation of the processes and their discharges considering all media. The status of this program and preliminary results are presented.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Pollution Control	13B
Coal Gasification	Stationary Sources	13H
Coal	Environmental Assessments	21D
Liquefaction		07D
Assessments		14B

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release to Public	**Unclassified**	8
	20. SECURITY CLASS (This page) **Unclassified**	22. PRICE A02-A01

EPA Form 2220-1 (9-73)

REPRODUCED BY
NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

EPA-600/J-79-023
JOURNAL ARTICLE

COAL PROCESSING TECHNOLOGY:

Environmental Impact Of Synthetic Fuels Development

Here's a status report on EPA's Synthetic Fuels Program, an effort to assess the effect of coal liquefaction and gasification processes on health and the ecology.

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The U.S. Environmental Protection Agency (EPA) has initiated a comprehensive long-term program to evaluate the environmental effects of energy systems that produce gaseous and liquid fuels from coal. Called the Synthetic Fuels Program, it is being conducted by the Fuel Process Branch in the Energy Assessment and Control Division of the Industrial Environmental Research Laboratory at Research Triangle Park, North Carolina (IERL-RTP).

Technologies being evaluated include low/medium-Btu (heat content) gasification, high-Btu gasification, and liquefaction. The specific objectives of the program are:

1. Define the environmental effects of synthetic fuels technologies with respect to their multimedia discharge streams.

2. Assess the environmental effects of the streams with respect to health and ecological impact.

3. Define control technology needs for an environmentally sound synthetic fuels industry.

This article outlines the activities to date of the program's environmental assessment contractors and other IERL-RTP contractors and grantees in the six areas that comprise the assessment approach. Contracts with EPA for environmental assessment of synthetic fuels processes run for a three year period. Radian's initise contract for low/medium-Btu gasification began in March, 1976; Hittman's contract dealing with liquefaction began in August, 1976; TRW's contract concerning high-Btu gasification began in April, 1977. Progress is roughly in proportion to the start date for work by each contractor. Most of the work to date has been on current process technology background and environmental data acquisition.

An information survey and engineering analysis of data for processes under consideration make up the work to compile current process technology background. Activities include: characterization of technologies, assessment of processes to determine potential for near-term commercialization, determination of waste streams, and identification of control equipment requirements.

Results are available on characterization of technologies and assessment of processes to determine potential for near-term commercialization. Determination of waste streams and identification of control equipment requirements is ongoing for the processes with high potential for near-term commercialization.

Basics of processes are similar

The production of low/medium-heat content gas (150 to 350 Btu/scf, or 5.59 to 13.03 MJ/m^3) involves three basic operations: coal pretreatment, coal gasification, and gas purification. The specific processes used to satisfy the requirements of each of these operations will be determined mainly by the properties of the coal feedstock, the type of gasifier that is employed, and the site-specific economic and environmental factors associated with each application. A number of processes and their interrelationships are depicted in Figure 1. Organization of information about synthetic fuels processes into figures such as Figure 1 allows a modular approach to comprehensive environmental assessment.

High-heat content gasification involves the same basic operations that are used in the production of medium-heat content gas plus additional processes to produce a product gas having a higher heating value. The additional processes are shift conversion and methanation. Quenching for tar and oil removal and stringent acid gas removal are required in high-heat content gasification systems to meet product specifications and protect the methanation catalyst from being poisoned.

Production of synthetic liquids from coal, like that of synthetic gases, involves a coal pretreatment operation preceding the synthesis operation and a purification/upgrading operation following it. Extent of pretreatment and post-synthesis purification/upgrading depends upon which liquefaction process is used.

The many liquefaction processes that have been or are being developed can be classified in four major categories: 1) catalytic hydrogenation, 2) solvent extraction (including noncatalytic hydrogenolysis in the presence of a solvent), 3) pyrolysis and hydrocarbonization, and 4) indirect processes.

These categories encompass a wide variety of processing conditions. Although solid coal or a coal slurry is usually fed to the liquefaction operation, indirect processes involve first gasifying the coal. In all categories, an initial reaction may produce only a small portion of the hydrogenation needed to produce high quality liquid fuels. In addition, upgrading by extensive hydrogenation may be required. An alternative to extensive hydrogenation is production of a

0360-7275/79/1707-0073 $01.00 • 1979 AIChE

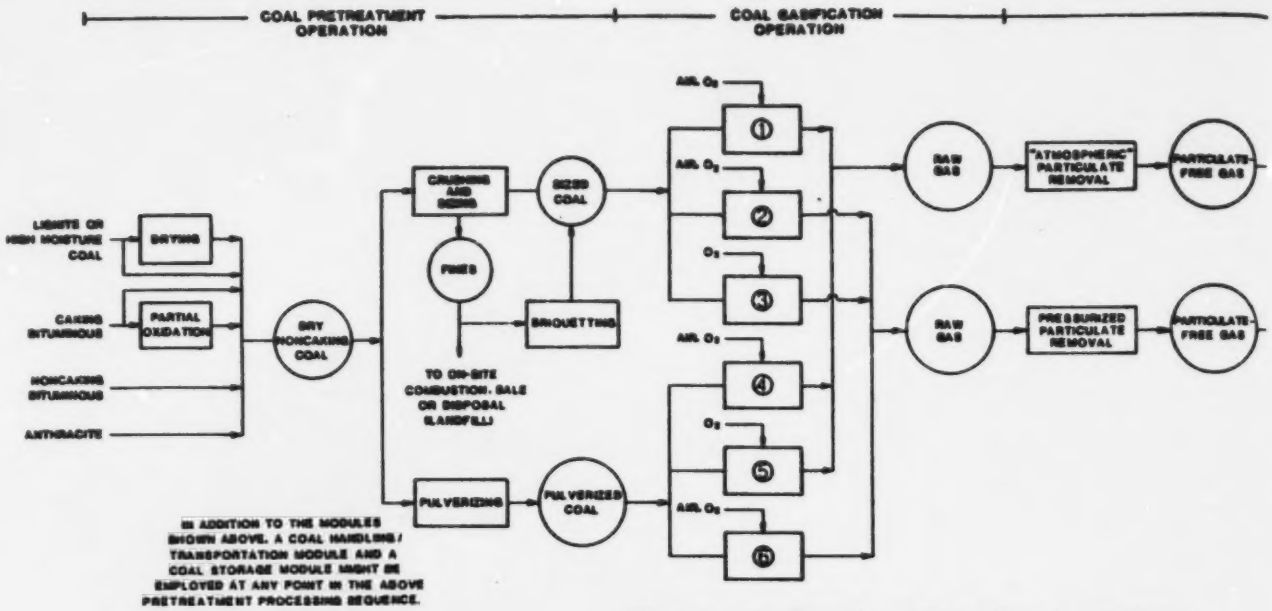


Figure 1. Low/medium-heat content coal gasification operations and processes.

utility fuel if it meets environmental and other requirements of utilities. Depending on the liquefaction process, varying amounts of carbon remain unreacted as char. Some processes use all the char to generate hydrogen by the steam-carbon reaction. Other processes produce such a high proportion of char that it must be considered a byproduct. Because of process dependent variations in all operations, coal liquefaction technology is less easily characterized than is gasification technology.

An important aspect of current process technology background is identification of processes that have a high potential for commercialization. This identification allows in-depth environmental assessment groundwork to be done with a good chance for follow-up environmental data acquisition at process demonstration sites. One criterion for this identification is whether development status is at the commercial level. Candidate processes associated with synthetic fuels production based on development status are discussed below.

Seventeen show commercial promise

For low/medium-heat content gasification, Radian Corp. has compiled a list of 17 gasifiers that appear to be the most promising candidates for satisfying near-term commercial needs. The candidates are in three groups. Those commercially available with a significant number of units operating in the U.S. or foreign countries are: Wellman-Galusha, Lurgi, Woodall Duckham/Gas Integrale, Koppers-Totzek, Winkler, Wellman Incandescent, and Foster Wheeler/ Stoic.

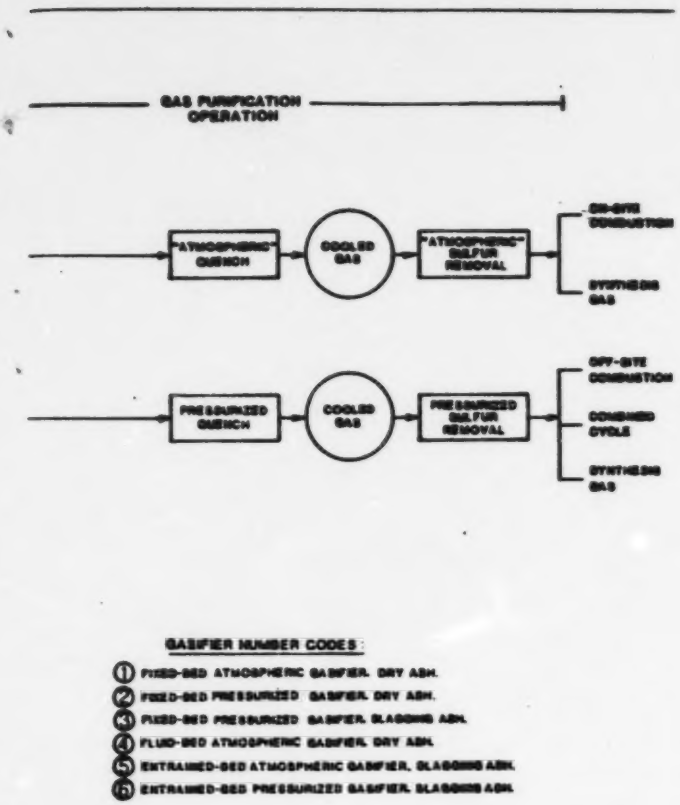
Units that have been commercially demonstrated in limited applications are: Chapman (Wilputte) and Riley Morgan. Although supported only by operation or construction of very few commercial or demonstration-scale units, technology judged promising and worthy of monitoring includes: Pressurized Wellman-Galusha (MERC), BGC/Lurgi Slagging Gasifier, Texaco, Combustion Engineering, Bi-Gas, Coalex, Kiln Gas, and Westinghouse.

For high-heat content gasification systems, economic reasons generally favor operation at high pressures. Of the commercially available processes, only the Lurgi process operates at high pressure. Development work is underway on several new high-pressure processes. The objectives of the work are process, economic, and environmental improvements over the Lurgi process. In their environmental assessment of high-heat content gasification, TRW has selected nine high pressure gasification processes for detailed analysis. These processes are: HYGAS, BI-GAS, COGAS, Hydrane, Synthane, Texaco, CO_2 Acceptor, Self-agglomerating Ash, and Lurgi.

Coal liquefaction is still in an early stage of development in the United States. Considerable work has been done at the bench, process development unit, and small plant scale, but no design-base presently exists for commercializing the technology. Hittman Associates have identified 14 processes as candidates for detailed study and environmental characterization.

Catalytic hydrogenation processes are the Synthoil, H-Coal and Bergius processes. Solvent extraction includes Solvent Refined Coal, CO-Steam, Exxon Donor Solvent and Supercritical Gas Extraction. Processes relying mainly on pyrolysis and hydrocarbonization are the COED, Coalcon, Clean Coke, TOSCOAL and Garrett Processes. Fischer-Tropsch Synthesis and Methanol Synthesis are indirect processes. At this time, the Solvent Refined Coal I (solid product), Solvent Refined Coal II (liquid product), H-Coal and Exxon Donor Solvent processes have been or are to be demonstrated.

Coal pretreatment and purification/upgrading are essen-



tial to the production of synthetic fuels. Of interest is the status of processes that may be required for pretreatment and purification/upgrading. Pretreatment may include crushing and grinding, sizing, partial oxidation, pulverization, drying, and/or briquetting. Specific processes used will be determined by the properties of the coal feedstock and the type of synthesis operation. Pretreatment processes, with the exception of partial oxidation, have been used for years in the gasification, coal-fired electric utility and charcoal industries. Moreover, much work (e.g., the Synthane process) has been done to develop a reliable partial oxidation process for reducing the caking tendencies of certain types of coal. Therefore, all coal pretreatment processes can be regarded as commercially available.

Purification/upgrading processes to follow liquefaction are generally being developed as part of liquefaction process development. The degree of filtration, fractionation and hydrotreating required depends very much on the type of liquefaction process. Some experience is available from petroleum refining and chemical processing. After gasification, purification may include particulate removal, gas quenching and cooling, and acid gas removal.

The intended end-use of the product gas determines which of these purification steps to use. For example, for on-site combustion of low-heat content gas produced from a low-sulfur coal, only particulate removal may be required. For the production of high-heat content gas, extensive use of all three purification steps is required in conjunction with shift conversion and methanation.

Particulate and acid gas removal

Particulate removal from gasifier product gas is generally accomplished through the use of dry collectors such as cyclones or electrostatic precipitators and/or the use of water or oil scrubbers. Scrubbers are normally employed when tars and oils as well as other impurities such as ammonia must also be removed from the product gas. Moreover, the use of water or oil scrubbers cools the product gas. Other candidate cooling processes include waste heat boilers and air- or water-cooled heat exchangers.

Acid gas removal processes remove compounds such as H_2S, COS, CS_2, mercaptans, HCN and CO_2 from the product gas. In theory, either high-temperature (>150°C) or low-temperature acid gas removal processes can be used. High-temperature processes utilize such sorbents as iron oxide, dolomites, and molten metals. They may yield higher energy efficiencies, but are only in the early development stage. Thus, most existing and proposed gasification plants use low-temperature processes.

A variety of low-temperature acid gas removal processes are commercially available. Most processes were developed for use in the natural gas, refinery, and chemical process industries. There do not appear to be any insurmountable problems associated with their use in coal gasification plants. Radian Corp. has identified 14 acid gas removal processes as the most likely candidates for near-term commercial use in coal gasification systems:

- Physical solvent processes: Rectisol, Selexol, Purisol, Estasolvan, and Fluor Solvent.
- Chemical solvent processes: MEA, MDEA, DEA, DIPA, DGA, and Benfield.
- Combination chemical/physical solvent processes: Amisol and Sulfinol.
- Direct conversion process: Stretford.

Focus on pollution problems

The discussion above listed gasification and liquefaction processes as well as purification processes whose well-developed status makes them promising candidates for commercial applications. Other selection criteria can by used to allow a focus on only a few processes of highest priority for environmental assessment. These include attractive process cost and energy efficiency; wide range of applicability; high probability of successful development and application; and minimal adverse environmental impact.

Although work on current process technology background has used all of these criteria, minimal adverse environmental impact is especially appropriate. Applying this criterion requires consideration of discharges of pollutants into all media. The multimedia emissions from synthetic fuels operations range from conventional pollution problems such as coal dust emissions to such ill-defined problems as fugitive emissions. As part of the engineering analysis of the environmental impact of low/medium-heat content gasification, general descriptions of discharges were compiled for typical plants. Summaries for each of the basic operations are in Tables 1, 2 and 3.

Emissions and waste handling for coal preparation seem to present no problems that available technology cannot handle. However, compositions of air emissions from some heat-intensive coal preparation processes such as coal drying are uncertain. The gasification operation appears to be the most serious source of potential pollution problems. Coal feeding, ash withdrawal, and fugitive leaks from valves, flanges and fittings will release products from thermal processing of coal.

Gas purification also appears to present difficult control problems. Water contaminated with suspended and dissolved organics and inorganics results from gas cooling. Most acid gas removal processes produce a vent stream that is rich in H_2S. Blowdown streams from purification processes will contain products from degradation of reactants as well as contaminants from the preceding thermal processing of coal.

A high-heat content gasification facility should have

environmental problems similar to those of a low/medium-heat content facility that uses gas cooling and acid gas removal processes. Some differences can be expected from different pressures, temperatures, and other system factors. Shift conversion and methanation are expected to have negligible influence on environmental problems.

For coal liquefaction, available literature has been searched, keying on potential pollutants resulting from liquefaction processes and associated developments. Based on the study of coal-derived products, present indications of chronic effects from major pollutants are as follows:

1. Sulfur-containing constituents (in the reduced state) are present in a much greater variety and, in some cases, larger quantities than was anticipated. The ecological and health effects of reduced sulfur compounds have not been studied sufficiently.

2. Concentrations of polynuclear aromatic hydrocarbons are high. A detailed study of this fraction is called for to properly estimate its contribution to the general threat of industrial carcinogenicity.

3. A wide variety of weak concentrations of acidic components, as well as significant concentrations of suspected tumor promoters or co-carcinogens occur.

4. Nitrogen heterocyclics are present at substantial levels, suggesting the need for additional studies. High indole/skatole concentrations suggest the possible presence of carcinogenic dibenzacridine.

In summary, work on current process technology background has indentified processes of near-term concern. It also shows that few or no data exist on minor/trace pollutants in gaseous, liquid or solid waste streams including fugitive emissions. Few or no data exist on the health and ecological effects of the waste streams. Few data document the performance of control technologies that may be used to treat the stream.

Environmental data acquisition consists of site selection, environmental testing (chemical and biological) and data evaluation. Environmental testing for IERL-RTP programs is to use the three-level approach to conducting chemical and biological tests that is being developed at IERL-RTP.

Level 1 is a comprehensive screening step that provides semi-quantitative data (accurate within a factor of ± 2 or 3) on all influent and effluent streams. Level 2 testing is intended to provide a more detailed analysis of the environmental problems identified in the Level 1 test. The third level of testing involves continuous monitoring of selected priority pollutants identified in Level 1 or 2 tests. Techniques for data evaluation include pollutant identification and quantitation, process stream characterization, and assay techniques. Development of these techniques is continuing at IERL-RTP with results available to the Synthetic Fuels Program.

Radian has tested or arranged for environmental tests to be conducted at four low/medium- heat content gasification facilities. They involve Chapman (Wilputte), Lurgi, Wellman-Galusha, and Foster-Wheeler/Stoic gasifiers. During visits to these and several other potential environmental testing sites, Radian obtained grab samples of selected

Table 1. Discharges from low- and medium-Btu gasification systems: coal pretreatment operation.

Waste Stream Source	Waste Stream	Description	Remarks
Storage, Handling, and Crushing/Sizing	Dust Emissions	Air emission from coal storage piles, crushing/sizing and handling will consist primarily of coal dust. The amount of these emissions will vary from site to site depending on wind velocities and coal size.	Asphalt and various polymers have been used to control dust emissions from coal storage piles. Water sprays and enclosed equipment have been used to control coal handling emissions. Enclosures and hoods have been used for coal crushing/sizing.
	Water Runoff	The data on dissolved and suspended organics and inorganics in runoff water produced for coal storage piles and dust control or suppression processes are minimal.	Proper runoff water management techniques have been developed. More data on the characteristics of this waste water need to be obtained to determine the need for treating this effluent.
	Solid Wastes from Crushing and Sizing	This stream consists of rock and mineral matter rejected from crushing and sizing coal. There are few data concerning the trace components in this stream and the potential of these components to contaminate surface and ground waters is not known.	This waste has been disposed of in landfills. Leaching data need to be obtained to evaluate the potential environmental impacts associated with this solid waste.
Coal Drying, Partial Oxidation and Briquetting	Vent Gases	This emission will contain coal dust and combustion gases along with a variety of organic compounds liberated as a result of coal devolatilization reactions. There are currently few data on the characteristics of these organic species.	The organic compounds need to be characterized to determine whether this discharge stream needs to be controlled. Afterburners in addition to particulate collection devices may be required.

Table 2. Discharges from low- and medium-Btu gasification systems: coal gasification operation.

Waste Stream Source	Waste Stream	Description	Remarks
Coal Feeding Device	Vent Gases	There are currently no data on the characteristics of these gases. These vent gases may contain hazardous species found in the raw product gas exiting the gasifier.	Vent gases from coal feeders can represent a significant environmental and health problem. Control of these emissions is required; however, the characteristics of these gases need to be determined to implement an adequate control method.
Coal Gasifier	Start-up Vent Stream	There are currently no data on the composition of start-up vent stream. Depending on the coal feedstock, there may be tar and oil aerosols, sulfur species, cyanides, etc. in this stream; therefore, control of pollutants generated during start-up is required.	This stream can be controlled using a flare to burn the combustible constituents. The amount of heavy tars and coal particulates in this stream will affect the performance of the flare. Problems with tars and coal particles can be minimized by using charcoal or coke as the start-up fuel.
	Fugitive Emissions	There are no data available on these emissions. They can be expected to contain hazardous species that are in the raw product gas such as hydrogen cyanide.	These emissions will determine the extent of workers' exposure to hazardous species and define the need for continuous area monitoring of toxic compounds and personnel protection equipment.
Ash Removal	Vent Gases	There are currently no data on the characteristics of this discharge stream. This stream may contain hazardous species found in the raw product gas and may require control.	Many sources of contaminated water may be used for ash quenching. Therefore, volatile organics and inorganics may be released in these vent gases. Characterization of emissions is needed to define control technology elements.
	Spent Ash Quench Water	There are limited data on this discharge stream which will contain dissolved and suspended organics, and inorganics. This stream will require control.	Characterization of this waste stream is required to define control technology requirements. Further treatment of this stream is essential.
	Ash or Slag	There are limited data on the characteristics of the ash and slag, especially concerning the amount of unreacted coal, trace elements, and total organics.	Leaching tests need to be done on this solid waste to determine whether further treatment is necessary before ultimate disposal. The organic content of the liquor used to quench the ash may affect the final disposal of the ash.

liquid and solid waste streams. IERL-RTP Level 1 analytical procedures plus some additional analyses were run on these samples.

The testing to date has achieved several objectives. Level 1 sampling and analytical procedures along with other techniques have been used to characterize process and emissions streams from low/medium-heat content gasification plants. Data for fugitive emissions from gasifier pokeholes have been collected. Control technology data on the effectiveness of a hot cyclone for removing particulates from the product gas have been evaluated.

TRW is seeking sites to do environmental sampling and analysis of high-heat content gasification. A list of domestic and foreign installations suitable for testing has been prepared. Candidate facilities are being contacted to determine the best possibilities for field testing.

Environmental data acquisition from liquefaction processes is not as far along as that from gasification facilities. One reason is that there are fewer liquefaction sites than gasification sites. More concern has been concentrated on collecting the data available in the literature. These efforts have shown that existing data on the environmental discharges of the different processes are fragmentary.

Preliminary estimates of such discharges are being done

for four processes: Solvent Refined Coal, Synthoil (begun before recent diminished interest), H-Coal, and Exxon Donor Solvent (EDS). Stack gas emission samples were collected and analyzed for a combustion test of solid solvent refined coal (SRC-I). A multimedia sampling test plan is also being prepared for the SRC-II pilot plant.

EPA research grants with funding from the Synthetic Fuels Program are also contributing to environmental data acquisition. North Carolina State Univ. (NCSU) will operate a gasifier/gas cleaning facility that uses about 50 lb/hr (23 kg/hr) of char or coal. By analysis of data from the facility, NCSU will evaluate the environmental effects of processes to clean raw gasifier product gas of particulates, condensibles and solubles and subsequent processes for acid gas removal. The facility was dedicated on October 26, 1978.

Under an EPA research grant with funds from the Synthetic Fuels Program, researchers at the Univ. of North Carolina (UNC) at Chapel Hill are seeking to assess the environmental impact of waste water contaminants originating from the production of synthetic fuels from coal. Biodegradation and other treatment schemes for coal conversion waste waters are being evaluated for the major components alone and in mixtures. Analysis of residual mixtures after treatability studies contributes to environmental data. Moreover, algal and fish bioassay tests are being done on components and their mixtures in the residuals left after treatment.

In another research grant, Research Triangle Institute (RTI) has initiated a program to characterize the pollutants contained in the product gas output stream from a laboratory gasifier. The RTI program will consist of three phases: screening studies, parametric control evaluations and research into kinetics of pollutant formation. The screening studies will consider, qualitatively, the variety of chemical compounds produced during gasification reactions. RTI has shown that up to 300 different compounds may be screened in the course of these tests.

In the parametric studies, the impact of reactor operation upon product gas pollutant levels will be examined. Parameters to be considered include type of solid feed, grind size, pretreatment method, bed depth, temperature, pressure, steam flow rate, residence time, and the presence of the catalysts and additives. Solid feed varies from peat and lignite to high-chlorine bituminous coal. Other variables such as bed type (fixed, entrained, fluidized) and reactor type (batch, semi-batch, plug flow, mixed flow) will also be considered. The reaction kinetics phase of the research program is being planned.

Environmental objectives development

The Synthetic Fuels Program benefits from a laboratory-wide effort at IERL-RTP to develop a workable system of evaluating and ranking pollutants for environmental assessment. Research Triangle Institute under contract with EPA has begun use of a technical approach that allows extrapolation through simple models using various data on health

Table 3. Discharges from low- and medium-Btu gasification systems: gas purification operation.

Waste Stream Source	Waste Stream	Description	Remarks
Particulate Removal	Collected Particulate Matter	There are few data on the characteristics of this solid waste stream, which will contain unreacted carbon, sulfur species, organics and trace elements.	Characterization of this stream is needed to determine whether it can be used as a byproduct or whether further treatment is necessary before disposal. Current data indicate that there is a significant amount of unreacted carbon in this stream and it may be used as a combustion fuel.
Gas Quenching and Cooling	Spent Quench Liquor	There are few data on the composition of this stream; however, current data indicate that there are significant quantities of suspended and dissolved organics (primarily phenols) and inorganics present.	Characterization of this stream will determine the type of water pollution control techniques required to treat the spent quench liquor. These techniques will vary depending upon the quantity and composition of this effluent stream.
Acid Gas Removal	Tail Gases	There are few data on the composition of these tail gases, which will contain sulfur species and hydrocarbons.	These gases are the primary feedstock to the sulfur recovery and control processes. Trace constituents such as hydrocarbons, trace elements, and cyanides will affect the performance of these sulfur recovery processes.
	Spent Sorbents and Reactants	No data have been reported on these streams, which will contain hazardous species such as cyanides, heavy metals, and organics and will require further treatment before disposal.	Characterization of this stream is required if it is to be treated using on-site pollution control devices.

and ecological effects. Threshold Limit Values (TLV is copyrighted by the American Conference of Governmental-Industrial Hygienists) and lethal doses are typical data that are available. Products of the models, called Multimedia Environmental Goals (MEG's), are interpreted as levels of significant contaminants or degradents in ambient air, water or land or in emissions or effluents conveyed to the ambient media that are judged to be: 1) appropriate for preventing certain negative effects in the surrounding populations or ecosystems, or 2) representative of technically achievable control limits.

Both ambient level goals and emission level goals based on ambient factors have been produced for specific elements or compounds of interest to coal conversion studies. Existing or proposed federal standards, criteria, or recommendations are used when they apply. Otherwise empirical data have been used that concern toxic potential, reactions and associations of each substance with the various media, natural background levels, and conditions for emission or dispersion of each substance.

Plans are to compile MEG's for more than 650 pollutants. Of these, 216 have received full attention in charts of MEG's published to date. For most of the remaining 434 substances, Minimum Acute Toxicity Effluent (MATE) values have been generated, even though they are based on extremely limited research. MATE's describe very approximate concentrations for contaminants in source emissions to air, water or land that will not evoke significant or irreversible harmful responses in human populations or ecosystems that might be exposed, provided the exposures are of limited duration.

Current environmental background includes two categories of data: current regulations that apply to the processes of interest; and the ambient levels of the pollutants expected to be emitted by the processes. Each contractor gathered data relevant to their area as part of the initial literature surveys with which they began their assessment activities.

A general compilation of current regulations was undertaken for the Synthetic Fuels Program by Pullman Kellogg in contract work on waste stream disposal and utilization. Federal, state, regional and international environmental standards were gathered. Moreover, Research Triangle Institute prepared a summary of key federal regulations and criteria for multimedia environmental control of coal conversion discharges.

For Lurgi gasification facilities, some guidelines for regulation exist at the federal level, although standards are not likely to be promulgated in the near future. At the state level, New Mexico has published standards for commercial gasification facilities. In the liquefaction area, Hittman Associates made a review of existing state regulations for those states that have enough demonstrated coal reserves to provide sites for commercial coal liquefaction facilities. The major conclusion of the review is that no legislation currently exists that pertains directly to regulation of coal liquefaction processes.

Prior to commercialization, regulation might be necessary at the federal, state, and local levels. Existing standards governing related fossil fuel technologies and data generated during environmental assessment could serve as the foundation on which standards for liquefaction facilities would be based. However, at this time it is impossible to project how stringent and how comprehensive environmental regulations will be in this area.

Control technology assessment

In EPA contract work on coal conversion waste stream disposal and utilization, Pullman Kellogg has sought to define potential environmental problems associated with fuel conversion processes. Literature searches and contacts with process operators were used to ascertain composition and quantity of typical discharge streams from coal conversion processes. The focus was on development of control technology for the streams.

A goal of an EPA research grant to the Univ. of North Carolina (UNC) at Chapel Hill is to provide criteria for the design of treatment plants that handle coal conversion waste waters. Alternative biological and physical-chemical treatment technologies for waste waters will be evaluated. The UNC researchers collected data from the literature on the composition of waste water from coal conversion processes. The data were organized according to major classes of compounds. This resulted in specification of a synthetic waste water, which is used for ongoing bench-scale work on biological treatment of coal conversion waste water and for acclimatizing microorganisms for component biological degradability tests. Real waste waters will be used in later work.

Under the EPA environmental assessment contracts, the contractors are to prepare Standards of Practice Manuals (SPM's) for specific coal conversion processes. The manuals are to provide an account of the status, capabilities, applicabilities, needs, and development schedule of control technologies and processes that may have use for synthetic fuels. Hittman Associates has completed an SPM that deals with the Solvent Refined Coal process. Control/disposal options have been selected for all waste streams. Pertinent federal, state, and local regulations have been projected relative to an assumed plant location on the Wabash River in White County, Ill.

Environmental alternatives analysis

This area like that of environmental objectives development, benefits from laboratory-wide development of methodologies for use in IERL-RTP environmental assessment programs. The aim of environmental alternatives analysis is to identify the best control options for an emission source and the best set of control options for a given plant. Source Analysis Models (SAM's) are being developed to relate the potential degree of hazard (PDOH) associated with a given emission from a stream or plant to defined environmental goals. By use of the models, various control options are to be easily and accurately compared. Sampling priorities can also be established, problem pollutants identified, and effluent streams ranked with respect to PDOH's.

To date, only the SAM/IA version is published. It is a method for rapidly screening each effluent stream to air, water or land from a specific source. The potential degree of health hazard from each pollutant in each gaseous, liquid, or solid stream is defined as the ratio of the pollutant's concentration in the stream to its health-based Minimum Acute Toxicity Effluent (MATE) value for each medium. The potential degree of ecological hazard is defined by using ecological MATE's. Potential toxic unit discharge rate (PTUDR) for each pollutant in each stream is defined as PDOH multiplied by the effluent stream flow rate.

In SAM/IA, transport to the external environment of components in the effluent stream is assumed to occur without any transformation of these components. The PDOH of a given stream is taken to be the sum of the PDOH's due to each pollutant. Similarly, PTUDR for a given stream is taken to be the sum of the PTUDR's for each pollutant in the stream.

Other SAM's will include techniques for effluent transport and transformation analyses. A draft version of SAM/I, an intermediate screening method, is undergoing review. SAM/I converts ambient-based, multimedia environmental goals to source discharge level goals by specifying appropriate concentration factors.

Overview of environmental R&D needs

The standards development efforts of EPA's Program Offices need the support offered by an adequate data base

on synthetic fuels technologies. Providing this support is a main purpose of IERL-RTP environmental assessment activities. Input from IERL-RTP can also help to identify applicable control technology. Generating this input is another purpose of the activities.

A significant part of the effort of EPA environmental assessment contractors is devoted to preparation of documents to fulfill these purposes. Besides the process-specific Standards of Practice Manuals (SPM's), which aid in control technology assessment, Environmental Assessment Reports (EAR's) are to address particular synthetic fuels systems. EAR's will specifically aim to provide the EPA Administrator, Program Offices, and Policy and Planning with recognized authoritative documents representing the EPA Office of Research and Development's up-to-date research input on standards. To date only a few SPM's and no EAR's have been published. Other documents have been issued, though, to report results in a timely fashion. A bibliography of relevant IERL-RTP reports can be found near the end of this article.

Most of the processes of interest for environmental assessments in the Synthetic Fuels Program are under development by industry and/or the Department of Energy. To help coordinate simultaneous environmental assessment and process technology development, the Standards Support Plan (SSP) for the Synthetic Fuels Program is a major planning document. This SSP will put forth an EPA plan of action regarding synthetic fuels that recognizes private sector/federal use or development, activities by EPA's Office of Research and Development, which includes IERL-RTP, and standards development by EPA's Program Offices. Furthermore, contractors and grantees for the Synthetic Fuels Program are encouraged to interact with each other and to develop professional working relationships with sponsors and owners/operators of process development facilities.

The logical complement to environmental assessment is control technology development. When the first environmental assessment contract for synthetic fuels was made, the plan was to proceed simultaneously with environmental assessment and control technology development. Budgetary constraints since then have forced the decision to put a higher priority on environmental assessment activities. Since control needs are only identified and prioritized by environmental assessment activities, the hope is that funds will be available soon to allow control technology development to proceed. #

Bibliography

1. Acurex Corp., "SAM I: An Intermediate Screening Method for Environmental Assessment of Fossil Energy Process Effluents," Draft Report, EPA Contract 68-02-2160 (June, 1978).
2. Bombaugh, K. J., "Analyses of Grab Samples from Fixed-Bed Coal Gasification Processes," EPA-600/7-77-141 (NTIS PB 276 606/AS) (December, 1977).
3. Budden, K. T., and W. H. Zieger, "Environmental Assessment of Coal Liquefaction: Annual Report," EPA-600/7-78-019 (NTIS PB 278 333/AS) (February, 1978).
4. Cavanaugh, E. C., W. E. Corbett, and G. C. Page, "Environmental Assessment Data Base for Low/Medium-Btu Gasification Technology: Volumes I and II," EPA-600/7-77-125 a and b (NTIS PB 274 844/AS and 843/AS) (November, 1977).
5. Cavanaugh, E. C., and W. C. Thomas, "Environmental Assessment of Low/Medium-Btu Gasification: Annual Report," EPA-600/7-77-142 (NTIS PB 276 580/AS) (December, 1977).
6. Cleland, J. G. and G. L. Kingsbury, "Multimedia Environmental Goals for Environmental Assessment: Volumes I and II," EPA-600/7-77-136 a and b (NTIS PB 276 919/AS and 920/AS) (November, 1977).
7. Cleland, J. G., *et al.*, "Pollutants from Synthetic Fuels Production: Facility Construction and Preliminary Tests," EPA-600/7-78-171 (August, 1978).
8. Dorsey, J. A., L. D. Johnson, R. M. Statnick, and C. H. Lochmuller, "Environmental Assessment Sampling and Analysis: Phased Approach and Techniques for Level 1," EPA-600/2-77-115 (NTIS PB 268 563/AS) (June, 1977).
9. Ghassemi, M., and C. Murray, "Environmental Assessment of High-Btu Gasification: Annual Report," EPA-600/7-78-026 (NTIS PB 278 176/AS) (February, 1978).
10. Ghassemi, M., K. Crawford, and S. Quinlivan, "Environmental Assessment Data Base for High-Btu Gasification Technology: Volumes I, II and III," EPA-600/7-78-186 a, b and c (September, 1978).
11. Ghassemi, M., *et al.*, "Applicability of Petroleum Refinery Control Technologies to Coal Conversion," EPA-600/7-78-190 (October, 1978).
12. Gold, H., and D. J. Goldstein, "Water-Related Environmental Effects in Fuel Conversion: Volumes I and II," EPA-600/7-78-197 a and b (October, 1978).
13. Hammersma, J. W., S. L. Reynolds, and R. F. Maddalone, "IERL-RTP Procedures Manual: Level 1 Environmental Assessment," EPA-600/2-76-160a (NTIS PB 257 850/AS) (June, 1976).
14. Hangebrauck, R. P., "Environmental Assessment Methodology for Fossil Energy Processes," in Symposium Proceedings: Environmental Aspects of Fuel Conversion Technology, III (September 1977, Hollywood, Florida), EPA-600/7-78-063 (April, 1978).
15. Harris, J. C., and P. L. Levins, "EPA/IERL-RTP Interim Procedures for Level 2 Sampling and Analysis of Organic Materials," EPA-600/7-78-016 (February, 1978).
16. Hittman Associates, Inc., "Evaluation of Electrostatic Precipitator During SRC Combustion Test," EPA-600/7-78-129 (July, 1978).
17. Hittman Associates, Inc., "Standards of Practice Manual for the Solvent Refined Coal Liquefaction Process," EPA-600/7-78-091 (June, 1978).
18. Hittman Associates, Inc., "Technology and Environmental Summary for Coal Liquefaction," Draft Report, EPA Contract No. 68-12-2162 (April, 1978).
19. Page, G. C., *et al.*, "Environmental Assessment: Source Test and Evaluation Report—Chapman Low-Btu Gasification," EPA-600/7-78-202 (October, 1978).
20. Pullman Kellogg, "Federal and State Standards Report," Draft Report, EPA Contract No. 68-02-2198 (February, 1978).
21. Radian Corp., "Guidelines for Preparing Environmental Test Plans for Coal Gasification Plants," Draft Report, EPA Contract No. 68-02-2147 (March, 1978).
22. Robson, F. L., W. A. Blecher, and V. B. May, "Fuel Gas Environmental Impact: Final Report," EPA-600/7-78-088 (June, 1978).
23. Research Triangle Institute, "Summary of Key Federal Regulations and Criteria For Multimedia Environmental Control," Draft Report, EPA Contract No. 68-02-1325 (June, 1977).
24. Schalit, L. M., and K. J. Wolfe, "SAM/IA: A Rapid Screening Method for Environmental Assessment of Fossil Energy Process Effluents," EPA-600/7-78-015 (NTIS PB 277 088/AS) (February, 1978).
25. Singer, P. C., *et al.*, "Assessment of Coal Conversion Wastewaters: Characterization and Preliminary Biotreatability," EPA-600/7-78-181 (September, 1978).
26. Sinor, J. E., ed., "Evaluation of Background Data Relating to New Source Performance Standards for Lurgi Gasification," EPA-600/7-77-057 (NTIS PB 269 557/AS) (June, 1977).
27. Spaite, P. W., and G. C. Page, "Low- and Medium-Btu Gasification Systems: Technology Overview," EPA-600/7-78-061 (NTIS PB 279 641/AS) (March, 1978).

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